

Army-Baylor University
Graduate Program in Health and Business Administration

Operating Room Utilization at Frederick Memorial Hospital

A Graduate Management Project
Submitted to the Program Director
in Candidacy for the Degree of
Master of Health Administration
July 2007

By:
Jonathan A. Edwards, Major, MSC
Administrative Resident, Frederick Memorial Hospital
400 West Seventh Street
Frederick, Maryland 21701

20080304247

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.					
1. REPORT DATE (DD-MM-YYYY) 24072007		2. REPORT TYPE FINAL REPORT		3. DATES COVERED (From - To) JULY 2006 to JULY 2007	
4. TITLE AND SUBTITLE Operating Room Utilization at Frederick Memorial Hospital				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Edwards, Jonathan, A, MAJ, MS				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) 400 West Seventh Street Frederick, MD 21701				8. PERFORMING ORGANIZATION REPORT	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) US Army Medical Department Center and School BLDG 2841 MCCS-HFB (Army-Baylor Program in Health and Business Administration) 3151 Scott Road, Suite 1411 Fort Sam Houston, TX 78234-6135				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) 34-07	
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT The purpose of this research was to identify opportunities for improvement for Frederick Memorial Hospital operating room utilization rates. A logistical regression analysis was used to identify the impact of variables on operating room utilization rates and therefore help explain how or why some operating rooms incurred higher utilization rates than others. Potentially, this retrospective study can help identify areas of improvement that continue to exist in the operating room today. Data was gathered from 11 rooms in the surgical suite from 1 January, 2006 through 31 March, 2006. A total of 640 operating room days made up the unit of analysis. Four variables were found statistically significant at the .05 level as having an effect on the likelihood of achieving optimal utilization or not. It was determined that excessive available time was the primary factor for predicting a decrease in likelihood that an OR will achieve optimal utilization.					
15. SUBJECT TERMS operating room, OR, utilization, efficiency, logistics regression					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 49	19a. NAME OF RESPONSIBLE PERSON Education Technician
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER (include area code) (210) 221-6443

Acknowledgements

I am greatly appreciative of the opportunity afforded to me by Frederick Memorial Hospital (FMH) which enabled me to complete my residency with their organization. Specifically, Dr. Rose Labriola undertook my residency as a first ever endeavor between the Army-Baylor Health and Business Administration Graduate Program and FMH. Her actions provided unlimited access to ensure I had not only a great learning opportunity, but her guidance also helped to direct my residency in meaningful directions that I may not have had otherwise.

I am also greatly appreciative of the leadership and guidance of LTC John Rogers at the United States Army Medical Materiel Agency (USAMMA) as he served as a preceptor and mentor during my residency. His guidance and willingness to be flexible during a challenging residency was essential and deserves many thanks.

My academic advisor, MAJ Lee Bewley, was essential to ensure my analysis was meaningful. I appreciate his advice and direction as he helped to focus my efforts in times of need.

I also appreciate the continuous efforts of James Thomas, Kristen Malone, and Keith Hawkins at FMH, as their continuous efforts to gather data used in this study. James Thomas was also essential in developing my understanding of the processes within the OR that lead to the data used to make this study meaningful.

Lastly, I must thank my family, and especially my wife, for their patience as my residency required months of travel away from them only to finalize with a year long deployment. They have my heartfelt appreciation for their patience and continued support, and they deserve more than I can possibly offer for their sacrifices.

Abstract

The purpose of this research was to identify opportunities for improvement for Frederick Memorial Hospital operating room utilization rates. A logistical regression analysis was used to identify the impact of variables on operating room utilization rates and therefore help explain how or why some operating rooms incurred higher utilization rates than others. Potentially, this retrospective study can help identify areas of improvement that continue to exist in the operating suite today. Data was gathered from 11 rooms in the surgical suite from 1 January, 2006 through 31 March, 2006. A total of 640 operating room days made up the unit of analysis. Four variables were found statistically significant at the .05 level as having an effect on the likelihood of achieving optimal utilization or not. It was determined that excessive available time was the primary factor for predicting a decrease in likelihood that an OR will achieve optimal utilization.

Table of Contents

List of Tables.....	5
List of Appendixes.....	6
Introduction.....	7
Conditions Which Prompted Study.....	11
Statement of Problem	12
Literature Review.....	12
Purpose.....	19
Methods and Procedures.....	20
Results.....	26
Discussion and Recommendations.....	32
Conclusion.....	38
References.....	40
Appendixes.....	44

List of Tables

1. Code Sheet.....	23
2. Utilization Measures.....	26
3. Performance by Day of Week.....	28
4. Descriptive Statistics.....	29
5. Model Summary.....	29
6. Variables in the Equation.....	30
7. Classification Table.....	32
8. Percentage of OR Days Exceeding a Given Utilization Rate.....	33
9. Change in OR 2 Performance on Tuesdays.....	33
10. Reduced AMIN/OMIN Performance for OR 8.....	36

List of Appendixes

A. Tuesday OR Performance.....	44
B. Thursday OR Performance.....	45
C. % of OR Days Exceeding Given Utilization Rate by OR.....	46
D. Ideal Curve.....	47
E. % of OR Days Exceeding Given Utilization Rate by OR.....	48
F. Definitions.....	49

Introduction

The purpose of this research is to conduct an analysis of operating room utilization rates at Frederick Memorial Hospital (FMH). Defining and measuring the impact of variables on an outcome can help explain how or why some surgical services or operating rooms (ORs) incur higher utilization rates than others and may help managers address specific aspects of OR throughput and utilization. Managing utilization has the potential benefit of rendering the most efficient method of care while improving quality of care. Efficient delivery is continuously important as reimbursement rates are under extreme scrutiny by managed care organizations and the Department of Health and Human Services regulating Medicare reimbursement rates. Maryland is under even tighter restrictions as the Maryland Health Service Cost Review Commission (HSCRC) requires average case rates to remain below the equivalent National average Medicare rates. Efficient and quality focused organizations also benefit from recognition as "Centers of Excellence."

Background

Griffith and White (Griffith and White, 2002, p. 179) stated that "making your numbers" is the mantra of modern business. This statement is a reflection of the increasing focus to meet or exceed benchmarks that are measures of performance. Hospitals are businesses and require revenue to continue operation, and failing to attain benchmarks can result in increased costs and lost revenue to the organization. Failure to meet benchmarks for average length of stay, productivity, quality, employee satisfaction, patient satisfaction, patient outcomes, resource utilization, and many others can result in costs and reduced revenues and affect the viability of a hospital. All costs that are avoidable, primarily resulting from inefficiencies, can and should be eliminated.

Many methods of economic constraints have been utilized to manage health care costs. Managed care has used clinical pathways, controls tied to reimbursement rates, to reduce inefficiencies with overuse and underuse of healthcare resources (Canales & Macario, 2001). Managed care controls impact hospital revenue and operating margins as previously accepted business practices were scrutinized and changed to meet managed care requirements for reimbursements. Canales and Macario (2001) reported that the average operating (profit) margin for hospitals fell from 6.3% in 1997 to 2.7% in 1999. In efforts to improve operating margins, hospitals have sought areas to reduce costs through changed business practices, management techniques, group purchasing, process controls, clinical practice guidelines, new technology, as well as various methods to reduce inefficiencies.

Inefficiencies become necessary to control, especially when operating margins are shrinking. Avoidable costs can be realized by reducing inefficiencies and ultimately improve operating margins for the organization. Tyler, Pasquariello, and Chen (Tyler, Pasquariello, and Chen, 2003) noted the economic importance of keeping operating rooms full as operating rooms are a major revenue producing service line, for both inpatient facilities and outpatient facilities, and may generate nearly half of a hospital's revenues. Operating rooms are also known as a significant expense when resulting in idle time and even more when resulting in over-time. It becomes clear why an efficient and well utilized operating suite is economically desirable. Tyler et al. (2003) also claims that one hour of over-time costs approximately 1.5 times an hour of idle time. However, idle time is an inefficiency concern as it can result in potentially avoidable costs to the organization.

Despite an organization's financial objectives, whether a for profit organization or not for profit organization, an efficient and well utilized operating suite is important to all stakeholders.

Healthcare managers desire high utilization, patients desire short wait-times, patient's family members desire procedures to finish on time, surgical staff desires predictable schedules, and surgeons desire autonomy of practice. An efficient allocation and utilization of the surgical suite allows the hospital to effectively plan staffing schedules which can result in improved employee satisfaction, employee retention rates, and quality of care provided. An efficient allocation and utilization of time can potentially enhance patient satisfaction as well by minimizing delays and reducing family member anxiety incurred during excessive waiting.

Impact on Frederick Memorial Hospital

Frederick Memorial Hospital (FMH) is a healthcare system located in Frederick Maryland approximately 50 miles northwest of Washington DC and 50 miles west of Baltimore Maryland. FMH first opened more than one hundred years ago with a simple mission statement, "to provide a place that would care for the sick, comfort the injured, and provide peace of mind to all who live in a town called Frederick" (FMH Mission Statement, 2006). Since its inception, FMH has grown to a 248 bed, not for profit community hospital and healthcare system that spans 20 satellite facilities in the region, as well as a comprehensive, state-of-the-art cancer center. Historically FMH has been the only major inpatient medical facility in the region, but as state regulatory requirements continue to minimize the cost of care, the organization has been faced with the need to enhance efficiency to remain viable and meet regulatory requirements.

In addition to the focus on efficiency, FMH has remained committed to meeting the needs of the community and retaining high quality staff. FMH has also undergone nearly a complete transformation of new executive leadership that is responsive to the growing challenges facing the organization. FMH has taken steps to become recognized as a center of excellence for the community and staff. One example of its focus on excellence has been demonstrated by its

recognition for its oncology program by the American College of Surgeons as a Community Hospital Comprehensive Cancer approved program. FMH is also continuing to improve its services by the recent focus to increase their special care nursery and cardiac capabilities. The organization has also placed an emphasis on recruiting and maintaining a quality nursing workforce and has subsequently placed an emphasis on becoming a Magnet Recognized facility which is a demonstration of excellence in nursing services.

There are many specialty practices and certifications ranging from orthopedic to vascular to neurosurgery as well as a comprehensive joint and spine surgical program performed by FMH. Last fiscal year, FMH performed 13,634 surgeries with approximately 60% of those as outpatient surgeries encountered from July 2005 through June 2006. Approximately 80% of all surgeries performed were elective.

Maryland inpatient facilities are especially concerned with efficiency of operating rooms as the Maryland Health Services Costs Review Commission regulates hospital rates, both Medicare and non-Medicare rates. This regulatory responsibility has been granted by a Federal legislation waiver, contingent upon Maryland's ability to contain rates below the average national Medicare cost. HCSRC then places pressure on hospitals in the form of regulated rates assigned to each hospital based on historical data that includes case-mix and diagnosis related group (DRG) among other factors. These rates are therefore different between hospitals and further influences hospitals to minimize inefficiencies. However, as the continued path toward efficiency prevails, the concern among providers is with the effect on quality of care associated with the drive to reduce costs (Litvak and Long, 2000). While quality may be a concern, Swanberg and Fahey's (Swanberg and Fahey, 1983) claim that higher quality care is less costly because defects (complications) and rework of products and services are avoided may stand the

test of time as quality improvement programs in other industries have also shown that high quality drives economic efficiency.

The surgical suite at FMH consists of 12 total ORs. One OR is used for emergency OB cases, one is used for local anesthesia cases only, and one is a cystology room. Time is also allocated to an OR for emergency cases beginning at 12:30 PM through 11:00 PM throughout the week, and a second OR becomes available for emergency cases from 7:30 PM to 9:30 PM. The OR suite schedule consists of block times dedicated to 36 various surgical groups throughout any given month as well as open time available to all surgical groups. Surgical group utilization is monitored to allocate block time appropriately. Those surgical groups with low utilization rates or high utilization rates for two consecutive quarters are subject to adjustments to improve block time allocation to meet demand. FMH has also selected a series of benchmarks focusing on measuring start-time accuracy, individual OR utilization, and turnover times to monitor OR efficiency. This data is gathered from the OR information management system and reviewed by the perioperative committee to address issues appropriately.

Conditions that Prompted the Study

Overall utilization rates have been below the 80 - 85% window used by FMH as the benchmark for optimum utilization rates. FMH perioperative committee has also identified a major problem area as first case start-time delays primarily due to surgeon tardiness. The presentation of this data has caused some controversy between surgeons and staff as a result of differing opinions regarding validity of the data as well as how to define first case start-time measures. Despite differing definitions and perceptions, late starts for the first case of the day can significantly delay subsequent case start times creating inefficiencies. The OR also has a benchmark goal established at 25 minutes for overall room turnover, but it has not been

consistently attained. While there have been periods of meeting this benchmark, the average room turnover time reported for the past year was 29 minutes. In an attempt to become a “center of excellence”, FMH is determined to improve performance and operate optimally across its spectrum of services, in this case optimizing OR utilization.

Performance reports for the OR have shown that surgeons were the major cause of delays in surgical cases resulting in only 23% of first cases of the day starting on time for FY 06, nearly 65% of first cases of the day started within 10 minutes of projected start time. Delays improved for the first two months of fiscal year 2007 as 80% of the first cases of the day started within 10 minutes of scheduled start time. Five ORs tend to have optimal utilization rates while six ORs tend to have less than optimal utilization rates; the OB OR room was excluded. Performance reports have shown that when all rates are combined, excluding the OB OR, the overall utilization averages about 75%, below the optimal range established by FMH of 80-85%.

Problem Statement

The operating suite utilization rate is not meeting established benchmarks. Variations exist between OR utilization rates and some surgeons and staff also perceive that ORs are not performing optimally. If excess capacity or correctable variations exist, then avoidable costs can be realized. Why do some ORs perform better than others?

Literature Review

Variability in healthcare

Operation management methodologies have long understood the need to identify and reduce variability associated with assembly line systems and processing line rates (Pourbabai, 1993; Li & Wang, 1996). The airline industry has also conducted many studies to understand and compensate for variations and have used methods such as overbooking to become more efficient

with seat capacity utilization. Airlines expect that a given amount of passengers will not show resulting in higher fill of seats, ultimately leading to reduced costs of inputs while most of the time producing the same quantity of outputs.

Variability is inherent in all healthcare systems as patients, provider experiences, management, and quality are not homogeneous and varies greatly from the airline industry. However, it is important to identify where variability exists and to identify the variables that can be controlled so utilization of resources can be maximized. Healthcare administrators are concerned with managing variability in patient flow resulting from random patient arrivals and variable medical procedure times (Rohleder, Sabapathy, & Schorn, 2005). Litvak and Long (2000) explained variability as two types, natural variability which is random in nature, and artificial variability which is nonrandom and internally induced.

Litvak and Long (2000) further organized natural variability in healthcare into three broad categories of clinical (degree of patient care needs), flow (arrival rates), and professional variabilities (practitioner and organization capabilities). It becomes apparent that patients as well as healthcare systems are not all equal resulting in natural variability. Organizations may consider maintaining excess open time to buffer against the demand of uncertainty resulting from natural or artificial variation. Therefore, when available surgical time is optimally allocated and scheduled, excess time is minimized as well as over-time. However, hospitals that are too risk averse may incur opportunity costs while hospitals that are too aggressive may incur avoidable costs of overtime in addition to hidden costs associated with displeased employees.

Efficiency and Utilization

Canales and Macario (Canales and Macario, 2001) noted the need for a statistical method to evaluate management strategies to decrease variability in OR utilization. Strum, May and

Vargas (Strum, May, and Vargas, 2000) noted that a good statistical model for surgical procedure times is important for several purposes such that it can be used retrospectively, together with existing methods. Eliminating sources of variability and conducting outlier management where outliers are managed separately could help to improve utilization. Often, surgeons and staff try to improve efficiency on the day of surgery by moving cases around. However, those decisions may result in only minor changes in overall efficiency. Although efficiency problems are observed on the day of surgery, those inefficiencies are caused by events days to weeks before the day of surgery (Canales & Macario, 2001; O'Sullivan & Dexter, 2006). Haraden and Resar (Haraden and Resar, 2004) also identified that clinicians create excessive artificial variation from personal preferences and beliefs.

Efficiency refers to how well resources are used in achieving a given result and improves as resource inputs to produce a given output are reduced while output remains constant (Ransom, Joshi & Nash, 2005, p. 29). Santerre and Neun (Santerre and Neun, 2004, p. 5) further explained how production efficiency varies slightly to that maximum output is produced from limited resources because the best mix of inputs has been chosen to produce each good. This production efficiency occurs as a result of trade-offs between any two goods given a fixed stock of resources and technology (Santerre & Neun, 2004, pg 6). O'Sullivan and Dexter (O'Sullivan and Dexter, 2006) applies efficiency to the OR as the value that has been maximized when the inefficiency of use of OR time has been minimized. It becomes evident that many methodologies exist how to measure efficiency, but finding the optimal and acceptable ratio of inputs to outputs is essential.

Eppen, Martin, and Schrage (Eppen, Martin, and Schrage, 1989) stated that efficiency is associated with capacity so that capacity utilization is maximized. This research paper uses a similar concept whereby capacity is reflected as staffed ORs dedicated to support allocated and

open time per OR, per day. Therefore, achieving optimal utilization becomes the unit of analysis for which this study focuses.

Inefficiency occurs when the quantities of one good increase without reducing the other, often because some resources are idle or underutilized at some point. Exceeding the Pareto optimal point of efficiency is generally said to be attainable at some point in the future if some form of productivity-enhancing technology or inputs arise (Santerre & Neun, 2004, pg 6). However, it should be noted that extremely high utilization, exceeding the optimal point of efficiency, becomes inefficient as will be discussed in the next section. In this study, the optimal point of efficiency is reflected as the optimal utilization rate of 80% or greater.

Optimal Utilization

Tyler et al. (2003) conducted research to determine the optimum utilization rate of an operating room and concluded that economic considerations are the reason it is desirable to keep operating rooms fully used when staffed. Their study indicated that efficiency increases as variation decreases, and the OR is most efficient with utilization between 85% and 95%. However, when utilization begins to reach 90-95% and greater, delays and overtime costs may be incurred, and repeatedly running late is hard on staff morale and may make recruiting and retaining scarce staff more difficult. Trade off analysis must be considered when attempting to increase utilization rates above 90%.

Studies have (Tyler et al., 2003) used the concept of over-utilization and under-utilization to quantitate the quality of OR scheduling. Ultimately, optimized utilization results from a balance between efficiency from an economic standpoint, and patient satisfaction. Clearly, efficiency improves by increasing patient wait time and becomes most efficient when patients are waiting when the OR becomes available, so idle time is reduced. Changes such as cases of

different duration, changes in variability of case duration, emergencies, cancellations, and so on will decrease optimum utilization. To maximize utilization, factors such as the cost to the organization of asking patients to wait, cost of overtime, and the ability of surgeons to take cases to another suite must be considered (Tyler et al., 2003).

When conducting trade-off analysis, many issues should be considered so over-utilization is minimized. Dexter and Traub (Dexter & Traub, 2002b) noted the cost of over-utilized time includes direct costs of overtime and indirect costs of possible employee dissatisfaction, resignation, and recruitment. However, poorly managed scheduling can lead to under-utilization as well as over-utilization, resulting in unpredictable schedules for staff. Mueller and McCloskey (Mueller & McCloskey, 1990) identified the importance that reliable scheduling has on nursing job satisfaction. Failure to have predictability has been linked to employee turnover and poor employee satisfaction leading to hidden costs. Unpredictable hours and schedules were identified by Stachota, Normandin, O'Brien et al. (2003) as one of the primary reasons for nurses terminating their employment and turnover (Thompson & Brown, 2002). Extensive research demonstrates the importance of managing case scheduling.

Shi & Sing (Shi & Sing, 2004, p. 522) claim that under-utilization occurs when benefits outweigh risks or costs. They also state that over-utilization occurs when costs or risks of use outweigh benefits. Shi & Sing further described outcomes as a measure of healthcare effectiveness and can be expressed in terms of patient satisfaction, recovery, morbidity, mortality, malpractice litigation, among many other terms. These outcomes for effectiveness can also be an important method of measuring efficiency as well, so that efficiency can improve effective outcomes and minimize ineffective outcomes.

Potentially, a service with a given allocated time period could achieve 100% utilization if all surgical cases were homogeneous in duration and complexity, staff and equipment were always available and on time, patients are always on time and prepared, demand is consistent, and turn-over time is consistent. Scheduling would then be a result of identifying the appropriate trade-off of wait time to allocated time to establish a schedule. Since variation exists in all of these areas, identification and minimization of those variations is essential to improve utilization. The weight of each predictor variable on utilization and influences on other variables is also essential to understand.

To reduce inefficient allocation of time to operating rooms, many facilities have employed OR information management technology. Macario (Macario, 2006) noted that optimal OR time allocation needs to be based on particular historical service use combined with computer software. Future allocation based on historical use provides a good basis to predict case length by surgeon when a specific case type and surgeon are matched. Combinations of this type must also account for scheduling future cases. FMH does this with the incorporation of the PICIS OR information management system. However, technology alone cannot resolve all issues associated with inefficient throughput, but can provide essential data necessary to identify and more efficiently manage OR capacity. Additionally, the data gathered in this system is required to be valid and accurate to provide meaningful analysis.

Utilization Variables

Caution should be taken when attempting to manage the surgical suite and should focus on addressing variables that affect the ORs in review. A robust amount of research has been conducted addressing OR efficiency by means of appropriate surgical case scheduling, decreasing patient and surgeon waiting times, moving cases between ORs, the effects of

reducing turnover times on staffing costs, and increasing efficiency of use of OR time (O'Sullivan and Dexter, 2006). Weinbroum, Ekstein, and Ezri (Weinbroum, Ekstein, and Ezri, 2003) stated that the most significant barrier to real cost reduction in the OR is waste of surgical operating time. Wasted time was determined by evaluating the possible existence of periods of OR inactivity, idle time, and spill-over time and analyze the impact on OR performance and cost.

Mathematical optimization approaches of goal programming have also been used to improve patient flow by improving surgical service block scheduling (Rohleder, Sabapathy, and Schorn, 2005). The goal programming model demonstrated the ability to reduce variability of surgical patients and still meet the desired target hours of all surgical services. This is important to note as hospital scheduling has long been noted as a political problem that requires consensus management among all of the affected parties (O'Keefe, 1985).

Eppen, Martin, and Schrage (Eppen, Martin, and Schrage, 1989) stated that capacity can be planned to satisfy demand almost always, most of the time, or with the understanding that it typically will not be able to satisfy demand but will have a high level of utilization. Capacity refers to the total scheduled surgical hours allocated of which staff scheduling is built to accommodate. Efficiency is then associated with capacity so that capacity utilization is maximized (Eppen et al., 1989). In the OR, efficiency may therefore be said to be a function of accurate surgical scheduling, allocation and staff scheduling. This model assumes that there are no problems associated with staffing, that patients are homogeneous and demand is consistent. However, scheduling is complicated by variability inherent in the surgical procedures (Strum, May, and Vargas, 2000). Patients have varying degrees of anesthesia and surgical complexities as well as barriers to arriving on time, complying with pre-surgical requirements as well as vast other variations. Surgeons, staff and anesthesiologists also perform at different rates of speed and

have varying degrees of work practices to include cancellations and tardiness in addition to other latent influences that may contribute to utilization variations. According to Li and Zhang, Variability results in waiting, delays, and under-utilization (Li & Zhang, 2000).

Surgeons see turnover time as non-value added time, as it is a limit to actual operating time. Turnover time includes cleaning, supplying, checking the OR as well as retrieving and transporting a patient to the room and serves as a potential bottleneck to patient flow (Tarantino, 2004). Tarantino (2004) states that the turnover process is highly inefficient and time consuming and results in delays in the OR schedule. He also states that anxious patients and families have to wait longer before their scheduled procedure is performed and angry and frustrated surgeons have to adjust their schedules to accommodate the delays, or worse cancel cases due to lack of available time which may ultimately result in loss of revenue to both physician and hospital.

Purpose

The purpose of this research is to identify opportunities for improvement for FMH OR utilization rates. Defining and measuring the impact of variables on an outcome can help explain how or why some surgical services or ORs incur higher utilization rates than others and may help managers address specific aspects of OR throughput and utilization. Identifying factors contributing to variability in utilization from those with less variability can provide opportunities for process improvements to more effectively predict and manage cases and ORs. While FMH already uses a scheduling system that utilizes an average of the last ten like surgeries a surgeon has done, coupled with case mix to estimate surgery duration, this study may be of assistance to FMH perioperative services to determine where to focus resources to improve utilization rates. Utilization rates could potentially be improved by making meaningful changes in processes,

behaviors, technology or combination thereof. However, meaningful changes rely on valid and reliable data and analysis to be effective.

Maximizing OR efficiency and utilization requires all stakeholders to comply with established benchmarks and policies. Meaningful benchmarks that are clearly shared between surgeons and staff coupled with responsibility of surgeons and staff to place the patient first must be maximized. While scheduling can impact how effectively ORs are utilized, this study aims to address the question why do some ORs or surgical groups perform better than others regarding utilization?

Methods and Procedures

Unit of Analysis

The primary unit of analysis was individual operating rooms at FMH. While the operating suite consists of 12 ORs, only 11 were used in the study as one OR was dedicated entirely to obstetrics cases, primarily urgent cases. OR 8 was also used primarily for cases utilizing general anesthesia and consequently did not have block time allocated to a specific surgical group. OR 8 was retained within the study as cases were often moved to this OR in efforts to enhance efficiency on day of surgery in addition to incurring scheduled cases.

Data Collection

Data from 1 January, 2006 through 31 March, 2006 was obtained from the PICIS OR management information system and analyzed to reduce or eliminate missing data. Logistic regression can be affected by excessive blank cells and warrants reduction or elimination of blank cells to improve statistical significance.

Data was then imported to Microsoft Excel for manipulation and review revealing 3616 total surgical cases for this time period. Only elective cases were evaluated against operating

room utilization, so elective cases conducted within the surgical suite were separated, to exclude OR 11, totaling 2465 elective cases. This eliminated cases performed in other areas such as endoscopy rooms and cardiopulmonary rooms. Endoscopy cases were excluded from the study as dedicated endoscopy rooms exist and would potentially be better analyzed separately. None of the cases removed were performed by surgeons allocated time in the surgical suite while two cases remained that were not part of the surgical suite, but were performed in the PACU and were eliminated from this study. 2392 elective cases remained for the study accumulating 183,899 minutes of surgery case time within the 11 analyzed ORs.

Utilization is measured in many ways as literature suggests. This study utilized the actual minutes of case time, also called utilized minutes, divided by the total available minutes to an OR. Utilized minutes are calculated as the total number of minutes accumulated from the time a patient enters a room until the patient leaves the room. This factor is important to note as utilization is often calculated to include turn over time (TOT). It is also important to note that excluding TOT results in fewer ORs attaining optimal utilization. Available minutes (AMIN) were calculated as the sum of surgical group block time and allocated open time for specific ORs as outlined by the hospital surgical block schedule. AMIN that was scheduled on the surgical block schedule may not have been counted if no surgeries took place in the OR. When holidays occurred, some surgical groups elected to conduct surgeries and not observe the holiday so the surgical schedule was used to compute open minutes (OMIN), block minutes and AMIN. Therefore, ORs are assumed to have been staffed and all hours on the surgical block schedule are used when calculating utilization rates and other data whenever an OR has a surgical case, regardless if the case was scheduled or moved to the OR in an attempt to improve efficiency the day of surgery. After all data was transformed into useable variables in Excel, data was then

entered into the Statistical Package for the Social Sciences (SPSS) version 15 for statistical analysis.

Hypothesis Statement(s):

Null hypothesis (H_0): There are no variables predictive of ORs with optimal utilization rates.

$$H_0: \beta_1 = \beta_2 = \beta_3 \dots \beta_n = 0$$

Alternate hypothesis (H_a): At least one variable is predictive of ORs with optimal utilization rates.

$$H_a: \beta_1 \neq \beta_2 \neq \beta_3 \dots \beta_n \neq 0$$

β_n = variables used in the analysis and are displayed in Table 1.

Statistics:

A cross-sectional retrospective study was used to analyze relationships of variables that affect operating room utilization through the use of a logistic regression model. Logistic regression is a robust statistical analysis technique that does not require data to be normally distributed. A non-experimental design is considered the weakest of research designs when determining cause-effect relationships in relation to internal validity or causal assessment. However, this research design is a common and an accepted design for the posited research question and is useful to establish the relationship of exogenous explanatory variables on the endogenous variable of utilization.

Logistic Regression Analysis was used to find an equation that best predicts the outcome variable. This statistical tool is appropriate to study the research question seeking predictability of independent variables with respect to a dichotomous dependent variable as it is relatively free from restrictions on predictor variables. A dichotomous “dummy” dependent variable was created, reflecting that the desired “optimal” FMH utilization rate was achieved or not achieved

and coded as a 1 or 0 respectively. Achieved is defined as equal to or exceeding 80% utilization, while not achieved is defined as less than 80% utilization. 80% was selected as the measured outcome based on the acceptable utilization rate established by FMH as well as supporting literature. Predictor, or independent, variables of total available minutes, open minutes allocated, block minutes allocated, day of week, number of surgical clusters that used the OR, first cases starting within 15 minutes of start of day, turn over time within 30 minutes, number of cases performed, among others, were analyzed to determine their relationships with utilization rates. A complete list of variables is displayed in table 1.

Table 1

Code Sheet

Equation Coefficient	SPSS Variable Code	Label	Description	Operationalized	Data Source
Y	AOU	Achievement of Optimal Utilization Rate	Achieved the optimal utilization rate of $\geq 80\%$.	Nominal data 1=Optimal 0=Suboptimal	PICIS
X ₁	AMIN	Available Minutes	The number of minutes available to an OR, includes block time and open time.	Continuous data Expressed in scheduled minutes lost	OR Schedule
X ₂	BMIN	Block Minutes Available	The total number of block minutes allocated to an OR for a given surgical group on a given day	Continuous data Expressed in minutes	OR Schedule
X ₃	OMIN	Open Minutes Available	The total number of open minutes allocated to an OR on a given day	Continuous data Expressed in minutes	OR Schedule
X ₄	NGOR	Number of Surgical Groups Using OR	The number of different surgical groups using the OR on a given day.	Continuous data Expressed in whole numbers	PICIS
X ₅	NCUO	Number of Surgical Clusters using OR	The number of different surgical clusters using OR on a given day	Continuous data Expressed in whole numbers	PICIS
X ₆	NCAS	Number of Cases per OR	The total number of cases conducted in the OR	Continuous data Expressed in minutes	PICIS
X ₇	Startdelay	First Start Delay	The number of minutes late the first case of the day started from scheduled time the OR is to open.	Continuous data Expressed in minutes	PICIS
X ₈	Monday	Monday	The day of the week an OR was open and utilized for this study.	Nominal Data 1=Monday 2=Not Monday	PICIS & Calendar
X ₉	Tuesday	Tuesday	The day of the week an OR was open and utilized for this study.	Nominal Data 1=Tuesday 2=Not Monday	PICIS & Calendar
X ₁₀	Wednesday	Wednesday	The day of the week an OR was open and utilized for this study.	Nominal Data 1=Wednesday 2=Not Monday	PICIS & Calendar
X ₁₁	Thursday	Thursday	The day of the week an OR was open and utilized for this study.	Nominal Data 1=Thursday 2=Not Monday	PICIS & Calendar
X ₁₂	Friday	Friday	The day of the week an OR was open and utilized for this study.	Nominal Data 1=Friday 2=Not Monday	PICIS & Calendar

Model significance was determined using an alpha (α) of .05 to assess how well the variables predict probability of achieving optimal utilization. Therefore, only one variable is required to attain significance to reject the null hypothesis. Variables are operationalized on the code sheet (see Table 1), and the relationship between the dependent variable and independent variables is represented in the following equation used in this study:

$$P(Y=1) = e^{(\alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n)} / 1 + e^{(\alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n)}$$

$P(Y=1)$: Probability of Achievement of Optimum Utilization ($>80\%$)

α : Intercept (value of Y when $X = 0$)

β_n : Slope Coefficient (y-intercept if all other constants are zero)

X_n : Independent variables represented in table 1

e: Random error generated in regression analysis

Probability (P) can also be determined by converting the odds to the probability that ($Y=1$) by the formula $P(Y=1) = [\text{odds that } Y=1] / [1 + \text{odds that } Y=1]$ which is visible in the aforementioned equation.

Variable relationships of logistic regression can also be expressed by the following equation showing its similarity to linear regression equations, but provides a less intuitive use of information generated:

$$\text{logit}(Y) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6$$

$\text{logit}(Y)$: Optimum Utilization ($\geq 80\%$)

α : intercept (value of Y when $X = 0$)

β_n : slope Coefficient (y-intercept if all other constants are zero)

X_n : Independent variables represented in table 1

The logit(Y) equation can be converted to the odds, expressed as likelihood, that $Y=1$ by using the exponent of the logit(Y) equation and produces the following equation which can then be used in the first equation to determine probability:

$$\text{Odds}(Y=1)=e^{(\alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n)}$$

There are two primary goals of the analysis. The first goal is to determine if there are variables that significantly predict ORs achieving optimal utilization. This information, assuming significance is identified, can then provide a basis to determine variation among ORs and provide a basis by which future analysis can help determine further improvement areas for FMH. Secondly, the information and conclusions drawn can lend to improving how the operating room is currently managed to improve utilization rates.

Validity and Reliability

Validity is a measure of the quality of the variables used to describe a construct. This test assumed many variables that would normally be associated with utilization rates which are subjective in nature, possibly undermining the importance of those variables and degrading construct validity of the test. However, construct validity is supported by much literature regarding the variables used in this study. Content validity is primarily a measure of how well information is entered into PICIS for FMH and is expected to be high as data is entered in the PICIS system concurrently with surgeries but relies on the integrity of the nurse entering the data. Much of the collected data has frequently been used to measure performance and evaluated to ensure accuracy which should further indicate increased validity of data.

The quantity of OR days used for this study is expected to increase reliability in addition to a cross-sectional analysis. Additionally, all OR days are measured the same and are only

suggestive of predictability for FMH OR utilization rates and are not expected to be reflections of ORs for other organizations.

Ethical Consideration

Patient and provider information was coded to ensure anonymity. All information was coded to identify trends or predictable variables only, not to identify specific practices of individuals.

Results

The 11 ORs utilized in this study reflect some interesting characteristics that should be discussed. Table 2 reveals a cumulative utilization rate for each OR for the quarter studied and a column that represents how many times an OR achieved optimal utilization. ORs 7, 8, and 12 all have achieved optimal utilization four times or less which may indicate a more serious indication of inefficiency. Those three ORs subsequently had the lowest utilization rates as well. While OR 7 achieved optimal utilization 4 times total it also, OR 8 achieved optimal utilization zero times.

Table 2

Utilization Measures

ROOM	Available Minutes	Utilized Minutes	Utilization RATE	Frequency Achieved Optimal Utilization	Number of Cases Performed
1	34800	19828	57%	13	277
2	35940	20000	56%	10	270
3	23880	11515	48%	6	170
4	32760	20206	62%	17	277
5	38340	22242	58%	11	222
6	27870	22670	81%	31	228
7	19920	9035	45%	4	124
8	23700	7728	33%	0	141
9	32820	20445	62%	16	201
10	31140	19355	62%	15	245
12	25200	10875	43%	2	237
Total	326370	183899	56%	125	2392

The interesting results of the low frequency of achieving optimal utilization may be a reflection of the scheduling methods used for those ORs. OR 7 has a high number of short block times scheduled and has the least number of available minutes, while OR 8 is scheduled for local anesthesia cases and has the second least number of available minutes, but is often used for cases that have been moved around as induced attempts to improve efficiency day of surgery. OR 8 is also the winner for lowest utilization rates which may be a clear indication that the amount of scheduled time for that OR is excessive. However, it should be noted that OR 8 was categorized as open time for scheduling cases and therefore never incurred any block time allocated to it.

Utilization was also analyzed for day of the week to determine if there was variation based on day of week. Table 3 displays the frequency of achieving optimal utilization by the day of the week and percentage of the total number of times optimal utilization was met. Tuesday displayed the lowest rate of achieving optimal utilization with Thursday closely following. However, Tuesday also incurred the highest number of OR days, indicating that more ORs were utilized on Tuesday than any other day of the week. This could indicate an inefficiency of using too many ORs on Tuesday at low capacity. Tuesday averaged 12 OR days, but never had any days where the OR met optimal utilization for ORs 2, 4, 7, 8 and 12. OR 7 also incurred less OR days on Tuesday totaling 8 days only while the average number of days and OR was used was 12 days and 2 days of achieving optimal utilization. OR 9 had the most days of optimal utilization at 33% with OR 1 & 6 closely behind at 31% of the OR days achieving optimal utilization.

Appendix A graphically depicts the number of OR days incurred by each OR on Tuesdays.

Thursday averaged 13 OR days and again two days of optimal utilization, but ORs 3, 4, 5, 8, and 12 all had no days of achieving optimal utilization, while OR 3 incurred zero OR days. OR 3 would be expected to have no OR days as it is scheduled only for emergency obstetric

cases during the day and emergent cases in the evening. However, OR 1 achieved and astonishing 46% of their OR days as optimal, with OR 6 & 10 both demonstrating optimal utilization for 38% of their OR days. Appendix B graphically depicts the number of days incurred by each OR on Thursdays.

Table 3

Performance by Day of Week

		suboptimal		optimal		Total OR days
		frequency	Percent of Suboptimal Days	frequency	Percent of Optimal Days	
Day of Week	Monday	103	20%	27	22%	130
	Tuesday	113	22%	19	15%	132
	Wednesday	93	18%	28	22%	121
	Thursday	103	20%	23	18%	126
	Friday	103	20%	28	22%	131
	Total	515	100%	125	100%	640

Logistical Regression Statistical Significance

The data alpha (α) probabilities was set at the $p = .05$ level and then processed and analyzed using version 15 of the Statistical Package for the Social Sciences (SPSS). This alpha means that the risk of 5 samples out of 100, the null hypothesis will be rejected when it is true (type I error). A large sample can produce significant p values for small and unimportant effects (Pampel, 2000), but the data used in this study was not so excessive as to induce such inflation (see Table 4 for descriptive statistics).

Table 4

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Achieved optimal utilization	640	0	1	.20	.40
Available Minutes	640	270	720	509.95	126.42
Open Minutes	640	0	720	190.55	218.37
Block Minutes	640	0	720	319.41	203.88
Number of Groups that used OR	640	1	6	1.76	.91
Number of Clusters that used OR	640	1	6	1.38	.68
First Case Number of Minutes delay	640	0	755	29.34	76.57
Number of cases	640	1	11	3.74	1.53
Monday	640	0	1	.20	.40
Tuesday	640	0	1	.21	.40
Wednesday	640	0	1	.19	.39
Thursday	640	0	1	.20	.40
Friday	640	0	1	.20	.40
Valid N (listwise)	640				

This study focused on evaluating ORs based on the category of achieving optimal utilization of 80% or not achieving optimal utilization. Therefore, logistics regression provided an ideal model to measure variables against this dichotomous dependent variable. The analysis revealed a statistically significant model with approximately 25 – 40% of variation accounted for by the variables in the equation (table 5).

Table 5

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	449.290(a)	.248	.396

a Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Friday was used as a referent category variable and therefore is not included in the reported statistics. Four variables were found to be statistically significant consisting of available minutes (AMIN), open minutes (OMIN), startdelay, and number of cases (NCAS). Table 6

displays the significance of the variables as well as the practical side of using logistics regression with the $\exp(B)$ and B for the significant variables. Three variables decrease the likeliness of achieving optimal utilization while one variable dramatically increases the likeliness of achieving optimal utilization.

Table 6

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1(a)	AMIN	-.012	.001	79.903	1	.000	.988
	OMIN	-.002	.001	6.267	1	.012	.998
	NGOR	.153	.182	.703	1	.402	1.165
	NCUO	-.080	.234	.116	1	.733	.923
	startdelay	-.012	.005	6.080	1	.014	.988
	NCAS	.439	.082	28.482	1	.000	1.551
	Monday	.021	.366	.003	1	.954	1.021
	Tuesday	-.387	.390	.986	1	.321	.679
	Wednesday	.422	.383	1.217	1	.270	1.525
	Thursday	-.264	.364	.526	1	.468	.768
	Constant	2.950	.683	18.637	1	.000	19.114

a Variable(s) entered on step 1: AMIN, OMIN, NGOR, NCUO, startdelay, NCAS, Monday, Tuesday, Wednesday, Thursday.

AMIN was statistically significant at the .05 alpha level. The $\exp(B)$ indicates a negative association with achieving optimal utilization. For each one minute increase in available minutes, a 1.2% decrease in the likeliness of achieving optimal utilization occurs.

OMIN was also statistically significant at the .05 alpha level. Though not as strong as AMIN, OMIN reflects that for each minute increase in open minutes the likelihood of achieving optimal utilization decreases by .2%. An inference may be made that decreasing open minutes for a given day for a given OR performing poorly may increase the likelihood of achieving optimal utilization.

Startdelay was the last of the three statistically significant variable found to have a negative affect. Though not as strong as AMIN again, it was significant at the .05 alpha level. Startdelay reflects that for each minute later that an OR starts their first patient of the day, the

likelihood of achieving optimal utilization decreases by 1.2%. This is evident as an OR that has 700 minutes available can be delayed 83 minutes, and would effectively be 100% likely that it will not achieve optimal utilization by these statistics. 83 minutes multiplied by .012 equals 99.6% likelihood of not achieving optimal utilization. Assuming the OR with 700 minutes allocated is delayed 83 minutes, then only 617 minutes are left to complete cases. Ideally, 88% utilization could occur if all cases incurred no turn-over time, but more than 10% of the time is inherently spent on room turnover, so it is highly unlikely that optimal utilization will be achieved.

The last statistically significant variable produced with logistic regression analysis was the number of cases (NCAS) in an OR. NCAS was highly significant at the .05 alpha level. A positive association between the number of cases in an OR and the likelihood of achieving optimal utilization is no surprise. If capacity exists, but is not used, then there is no hope of achieving good utilization of resources. This study revealed that each case added to an OR increases the likelihood of achieving optimal utilization by 44%. The importance of ensuring resources are fully utilized and scheduled appropriately becomes very clear with this statistic.

The classification table displays (Table 7) the practical results of using the logistic regression model. For each case, the predicted response is "yes" if that case's model-predicted probability is greater than the cutoff value of .5. Of the cases used to create the model, 50 of the 125 ORs that achieved optimal utilization are classified correctly, while 501 of the 515 ORs that did not achieve optimal utilization are classified correctly. Overall 86.1% of the cases are classified correctly. This suggests that about 8 times out of 10 the model correctly classifies showing that it is much more reliable than guessing alone.

Table 7

Classification Table(a)

Observed			Predicted		Percentage Correct
			Achieved optimal utilization		
			0	1	
Step 1	Achieved optimal utilization	0	501	14	97.3
		1	75	50	40.0
Overall Percentage					86.1

a The cut value is .500

Discussion and Recommendations

The data showed that 125 of the 640 operating room days achieved optimal utilization of 80% or greater. Therefore, approximately 20% of the OR operating days achieved optimal utilization rates. Of the OR days that achieved optimal utilization, table 8 shows that 8.8% exceeded 100% utilization, indicating that those ORs incurred excessive, and possibly more inefficient, use as additional costs may have been incurred from overtime and among other latent costs. Exceeding 100% utilization means that the total case time exceeded the time allocated to that specific OR, according to the OR block schedule and fails to address TOT, delays, or any other time that may have been added to or removed from the OR day analyzed.

The data also revealed that of the 515 OR days that did not achieve optimal utilization, approximately 7% of the OR days incurred less than 20% utilization rates. Potentially, the ORs that incurred such low rates could have been diverted days before the surgery to another OR with lower anticipated utilization and increase utilization to an optimal rate for one OR. Of those 48 OR days that incurred less than 20% utilization, 41 can be attributed to ORs 3, 7, 8, and 12.

Initially, these results appeared to suggest that the overall use of resources may not have been used efficiently. A closer look at the utilization rates incurred by each OR appeared to suggest that those ORs that achieve optimal utilization the most frequently also exceeded 100%

utilization the most frequently. For example, table 8 reveals that OR 6 achieved optimal utilization of 80% or greater for 47.7% of its OR days, but it also exceeded 100% utilization for 32.3% of its OR days. OR 6 achieved optimal utilization for 31 of its 65 OR days, but 21 of those days also exceeded 100% utilization. As literature suggest, despite achieving optimal utilization rates desired by the hospital, another type of inefficiency related to overuse may cost an organization more than under-utilized time. When accounting for TOT, this OR could potentially be labeled as inefficient despite high utilization rates.

Table 8

Percentage of OR Days Exceeding a Given Utilization Rate by OR

OR/ Given Rate	≥10% Util	≥20% Util	≥30% Util	≥40% Util	≥50% Util	≥60% Util	≥70% Util	≥80% Util	≥90% Util	≥100% Util
1	100.0%	96.9%	92.2%	84.4%	67.2%	45.3%	29.7%	20.3%	10.9%	1.6%
2	98.4%	98.4%	88.9%	76.2%	58.7%	44.4%	25.4%	15.9%	11.1%	6.3%
3	100.0%	87.5%	75.0%	64.6%	47.9%	31.3%	22.9%	12.5%	8.3%	6.3%
4	100.0%	98.5%	95.4%	90.8%	69.2%	50.8%	36.9%	26.2%	23.1%	18.5%
5	100.0%	98.5%	90.8%	83.1%	67.7%	49.2%	27.7%	16.9%	9.2%	6.2%
6	100.0%	98.5%	96.9%	96.9%	95.4%	86.2%	63.1%	47.7%	35.4%	32.3%
7	91.1%	80.0%	71.1%	60.0%	51.1%	28.9%	11.1%	8.9%	6.7%	2.2%
8	82.4%	66.7%	43.1%	33.3%	23.5%	17.6%	5.9%	0.0%	0.0%	0.0%
9	100.0%	100.0%	95.2%	87.1%	67.7%	50.0%	38.7%	25.8%	19.4%	12.9%
10	100.0%	96.7%	93.4%	88.5%	73.8%	54.1%	36.1%	24.6%	11.5%	3.3%
12	92.2%	84.3%	72.5%	56.9%	43.1%	23.5%	7.8%	3.9%	0.0%	0.0%
Total	97.2%	92.5%	84.7%	76.6%	62.2%	45.5%	29.2%	19.5%	13.1%	8.8%

ORs 7, 8, and 12 have the worst rate of achieving optimal utilization. While these three ORs have time scheduled on the OR block schedule, they are not the most well utilized ORs. Table 8 reveals that these three ORs contribute the least to achieving optimal utilization. Or 8 never even achieves optimal utilization for any of its 51 OR days. While OR 7 has the highest frequency of achieving optimal utilization among the three losers, it only achieves optimal utilization for 8.9% of its 51 OR days. Of the four days that OR 7 achieved optimal utilization,

one of those days exceeded 100% utilization. These three ORs also have the worst history of achieving a utilization rate of less than 10%. OR 8 is the worst of the three with 18% of its OR days achieving utilization rates below 10%. Appendix C graphically depicts a line chart with curves representing the data from table 8 as well as a graph visually depicting the desired curve. The desired curve reflects that 100% of available OR days achieve 10% or greater utilization starting on the left and dramatically drops between the 80% and 90% given rate. This drop indicates utilization is maximized as much as possible at 80% but is minimized by 90% and nearly non-existent at 100%. Curves sloping down prior to 80% on the x axis indicate potential inefficiencies as well as curves above zero on the far right.

Appendix C graphically shows that OR 8 starts below 100% on the left and continues to decrease at a rate faster than the desired rate suggesting that it is most inefficient. However, OR 6 most closely resembles the desired curve, but fails to diminish enough by 90% and ultimately incurs the highest overuse, with 21 of its 65 OR days exceeding 100% utilization. Appendix D isolates ORs 4, 6, 8, 9, and 10 to depict a clearer picture of best and worst performance against an ideal curve. This ideal curve assumes that the 80-90% utilization rate window is not only the desired window, but the best an OR can be expected to perform before over-utilization or under-utilization inefficiencies become excessive.

It appears that the greatest improvement could occur with the reduction of available OR minutes. The statistics suggest that available minutes have a statistically significant ability to reduce the likelihood of achieving optimal utilization by 1.2% for each minute increase in available minutes. Conversely, reducing available minutes may increase the likelihood of achieving optimal utilization by 1.2% for each minute decrease in available minutes. This coupled with the statistically significant "open minutes" variable suggesting the same ability to

reduce likelihood of achieving optimal utilization by .2% for each minute increase of open minutes. It may be inferred that excessive amounts of open minutes exist.

This excess time phenomena may occur as OR 8 has been categorized solely as open time as it does not incur block time for any surgical groups, rather it is open to any surgeon for cases requiring local anesthesia only. This OR has also been used to move regular cases in an attempt to improve efficiency on the day of surgery which may contribute to the incredibly low utilization rates noted, specifically 18% of its OR days incurred less than 10% utilization rates. This may also indicate that attempts to improve efficiency on the day of surgery actually decrease efficiency assuming all ORs are fully staffed.

Statistics indicate that each minute decrease in open minutes increases the likelihood of achieving optimal utilization by .2%. Therefore, decreasing open time for OR 2 by 90 minutes every Tuesday would equate to a 12% decrease in open minutes, and expected 18% increase in the likelihood of achieving optimal utilization. When this data is substituted for the data gathered, an extra OR day achieves optimal utilization. And utilization for OR 2 increased from 48% to 55% on Tuesdays. A reduction of 1080 total minutes occurred for this particular OR, equivalent to 18 hours.

Table 9

Change in OR 2 Performance on Tuesdays

	AMIN	OMIN	Case Min	Utilization Rate
Actual	8640	7020	4171	48%
Substituted	7560	5940	4171	55%
Difference	-12%	-15%	0	

The "startdelay" variable had a statistically significant value reflecting that every minute increase in start delay the likelihood of achieving optimal utilization decreases by 1.2%. This

utility of this significant finding applies very well to OR 8 in conjunction with the OMIN and AMIN variables. Approximately 51% of the cases that occurred in OR 8 started more than 60 minutes after the surgical block schedule indicates operational start time. Table 10 displays the potential results that starting 60 minutes later for every day, except Thursday, could improve utilization for OR 8. Since OR 8 is available for any surgical group to use for cases requiring local anesthesia, it was categorized entirely as OMIN time and therefore equivalent to AMIN time. Additionally, more than 50% of the cases started more than an hour after the surgical block schedule indicates it should start demonstrating further the predictive statistical results suggesting that every minute delay incurred that a reduced likelihood of achieving optimal utilization occurs. Therefore, reducing AMIN/OMIN and fitting the schedule to better meet the apparent scheduling methodology of longer surgical cases scheduled earlier in the day for a surgeon than later, an improved utilization rate could be expected to occur. Removing 60 minutes from the schedule every day, except Thursday, results in a decrease of 2280 available/open minutes. If applying the .002 B to the 2280 minutes, one would expect a 4.56% increase in utilization rates. Table 10 shows an over increase in utilization from 33% to 36%. 2280 minutes reduced is equivalent to 38 hours of reduced OR time for the quarter and slightly improved utilization for OR 8.

Table 10

Reduced AMIN/OMIN Performance for OR 8

	AMIN	Case Min	Util rate	# OR days	# days w/delay >60 min	New AMIN	New Util rate
Monday	2880	565	20%	6	4	2520	23%
Tuesday	5760	2634	46%	12	5	5040	52%
Wednesday	4320	1279	30%	9	4	3780	34%
Thursday	5460	1794	32%	13	6	5460	32%
Friday	5280	1456	28%	11	7	4620	32%
Total	23700	7728	33%	51	26	21420	36%

It becomes apparent that correctable scheduling and OR management inefficiencies exist in the surgical suite, but it should be noted that these results may be inflated as all of the OR days used may not be fully staffed OR days as assumed for this study. Many days of low utilization rates may exist from ORs that were technically not staffed but had cases moved to them in attempts to improve efficiency and therefore impact the reliability of the results. Despite some impact on reliability, the statistical results should not be dismissed as strong statistical significance lends validity to the impact the changes can have on utilization. Since inflation is possible, the examples demonstrated were kept to more modest increases. It is recommended that use of these results do not warrant dramatic attempts to improve utilization, rather small incremental changes should be implemented and measured against expected results to determine the true degree of impact such changes may have on utilization. Additionally, each OR should be carefully analyzed to determine the appropriateness of attempting to apply these statistics as all ORs are not the same, nor perform exactly the same. Changes should also incur a trade off analysis as surgical groups or surgeons may feel schedules are already inflexible.

The number of cases (NCAS) an OR has was also significant. Clearly, the more cases an OR has, the higher the utilization rate will be. This area warrants further analysis as many cases are moved around the day of surgery in an attempt to improve efficiency. A subsequent case may be moved to a different OR than scheduled so a surgeon falling behind can move to the next case faster in an attempt to improve efficiency. This move may artificially impact this study as an extremely low utilization rate may incur as this study assumed that an OR with a case in it is fully staffed and therefore counted in the study. It may also indicate that cases are more often moved to specific ORs and henceforth over-utilization occurs when the case should have been moved to another OR. This data can potentially incur an independent study of its own.

A further study of surgical group performance is also recommended. Though not demonstrated in this paper, it was noted that three of five surgical groups randomly chosen and more closely analyzed revealed that despite a surgical group achieving utilization rates for their block time was well above 100%, the actual number of minutes of case time utilized during their allocated block time was below 100%. This may be a further indication that excessive open time exists and that surgical group block time may warrant further analysis.

This study represents impacts of variables at a particular hospital and does not represent all organizations. However, the study lends utility to organizations concerned with identifying variables that may impact utilization at their facilities. Regardless of organization, efficient use of resources required to produce a desired output minimizes avoidable costs.

Conclusion

This analysis aimed to determine why some ORs perform better than others regarding utilization rates. The data showed that utilization is suboptimal for all but one OR according to the methodology used to calculate utilization in this study. It was determined that allocated time may be excessive for some ORs, more often excessive open time.

Start delays indicated that likelihood an OR will not achieve optimal utilization increases for each minute delay increase. However, it is an indication that scheduling, cancellations, or moving cases between ORs the day of surgery are more likely the culprit of cases starting later than the surgical block time schedule indicates as the OR start time. This is important to note as reducing TOT from 35 to 25 minutes is expected to increase the likelihood of achieving optimal utilization by 2%. Since the TOT goal is 25 minutes, a maximum of a 4.6% increase in likelihood of achieving optimal utilization can occur as the average TOT is 48 minutes. The 48 minute average TOT is grossly inflated as nearly 10% of all TOT was greater than 90 minutes

indicating gaps in scheduling, cancellations, or other delays. A larger benefit can be achieved by identifying and correcting gaps in the ORs than focusing on TOT as a benchmark goal.

This study indicates that inefficiencies exist in scheduling, block allocated time, open allocated time, and process used to move patients between ORs the day of surgery. While further study is warranted in some of these areas, this study provided some sound statistical tools that can benefit the surgical suite. The results also have demonstrated the utility of logistic regression when analyzing variables that can impact performance. The results reported herein should help to appropriately match required resources to a desired outcome as well as provide utility to both civilian and governmental organizations to manage the increasingly daunting task of maintaining and improving efficiency.

References

- Blake, J., Dexter, F., & Donald, J. (2002). Operating room managers' use of integer programming for assigning block time to surgical groups: a case study. *Anesthesia and Analgesia*. 94, 143-148.
- Canales, M., Macario, A. (2001). Can peri-operative quality be maintained in the drive for operating room efficiency? *An American Perspective*. 15(4), 607-619.
- Dexter, F., Macario, A., Lubarsky, D., Burns, D. (1999). Statistical method to evaluate management strategies to decrease variability in operating room utilization. *Anesthesiology*. 91(1), 262-274.
- Dexter, F., Blake, J., Penning, D., & Lubarsky, D. (2002a). Calculating a potential increase in hospital margin for elective surgery by changing operating room time allocations or increasing nursing staffing to permit completion of more cases: A case study. *Anesthesia and Analgesia*. 94, 138-142.
- Dexter, F. & Traub, R. (2002b). How to schedule elective surgical cases into specific operating rooms to maximize the efficiency of use of operating room time. *Anesthesia and Analgesia*. 94, 933-942.
- Dexter, F., Marcon, E., Epstein, R. (2005). Validation of statistical methods to compare cancellation rates on the day of surgery. *Anesthesia and Analgesia*, 101, 465-473.
- Dexter, F., Macario, A., & Traub, R. (1999). Which algorithm for scheduling add-on elective cases maximized operating room utilization. *Anesthesiology*. 91(5), 1491-1500.
- Eppen, G., Martin, R., & Schrage, L. (1989). A scenario approach to capacity planning. *Operations Research*. 37(4), 517-527.

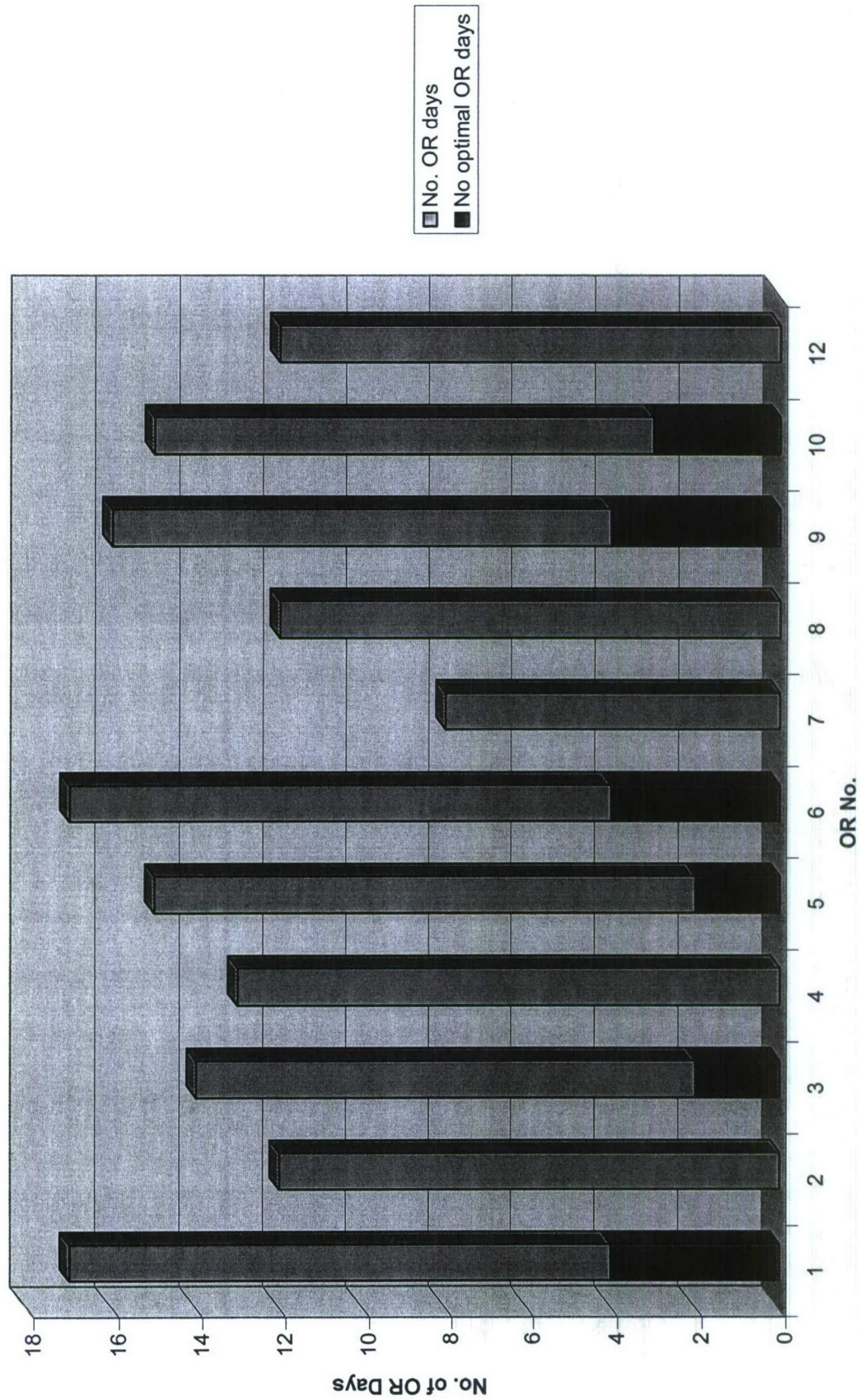
- Epstein, R., Dexter, F. (2002). Uncertainty in knowing the operating rooms in which cases were performed has little effect on operating room allocations or efficiency. *Anesthesia and Analgesia*. 95, 1726-1730.
- FMH Mission Statement. (n.d.). Retrieved September 2, 2006, from <http://www.fmh.org/body.cfm?id=327>
- Griffith, J., & White, K. (2002). Measuring performance (5th Eds.), *Well Managed Healthcare Organization* (5th ed.), (pp. 179). Chicago, IL: Health Administration Press.
- Haraden, C., & Resar, R. (2004). Patient flow in hospitals. *Frontiers of Health Services Management*. 20, 3-15.
- Kim, S., Horowitz, I., Young, K. et al. (2000) Flexible bed allocation and performance in the intensive care unit. *Journal of Operations Management*, 18, 427-443.
- Li, L., & Whang, X. (1996). The service facility startup and capacity model and its application to the national cranberry case. *Operations Research*. 44(1), 160-172.
- Li, L., Zhang, H. (2000). The multistage service facility start-up and capacity model. *Operations Research*. 48(3), 490-497.
- Litvak, E., Long, M. (2000). Cost and quality under managed care: Irreconcilable differences?. *The American Journal of Managed Care*, 6(3), 305-312.
- Lovejoy, W., & Li, Y. (2002). Hospital operating room capacity expansion. *Management Science*, 48(11), 1369-1387.
- Macario, A., (2006). Are your hospital operating rooms "efficient"? *Anesthesiology*, 105(2), 237-240.
- Mueller, C., & McCloskey, J. (1990). Nurses' job satisfaction: A proposed measure. *Nursing Research*. 39(2), 113-117.

- O'Keefe, R. (1985). Investigating outpatient departments: Implementable policies and qualitative approaches. *Journal of the Operational Research Society*. 36, 705-712.
- O'Sullivan, C., & Dexter, F. (2006). Assigning surgical cases with regional anesthetic blocks to anesthesiologists and operating rooms based on operating room efficiency. *American Association of Nurse Anesthetists Journal*. 74(3), 213-218.
- Pourbabai, B. (1993). An Operational strategy for throughput maximization and bottleneck control in an assembly line system: by selection of the processing rates. *The journal of the Operational Research Society*. 44(10), 1003-1011.
- Ransom, S., Joshi, M., & Nash, D. (2005). Basic concepts of healthcare quality. *The Healthcare Quality Book*, (pp. 29). Chicago, IL: Health Administration Press.
- Rohleder, T., Sabapathy, D., & Schorn, R. (2005). An operating room block allocation model to improve hospital patient flow. *Clinical and Investigative Medicine*. 28(6), 353-355.
- Santerre, R., & Neun, S. (2004). Introduction. *Health Economics: Theories, Insights, and Industry Studies* (3rd Ed.), (pp. 5). Mason, OH: Thomson South-Western.
- Shader, K., Broome, M., Broome, C., West, M., & Nash, M. (2001). Factors influencing satisfaction and anticipated turnover for nurses in an academic medical center. *Journal of Nursing Administration*. 31(4): 210-216.
- Shi, L. & Singh, D.A., (2004). Medical Technology. *Delivering healthcare in America: A systems approach* (3rd ed.), Sudbury, MA: Jones and Bartlett Publishers.
- Stachota, E., Normandin P., O'Brien N., Clary M., & Krukow B. (2003). Reasons registered nurses leave or change employment status. *Journal of Nursing Administration*. 33(2), 111-117.

- Strum, D., May, J., & Vargas, L. (2000). Modeling the uncertainty of surgical procedure times. *Anesthesiology*. 92(4), 1160-1167.
- Swanberg, G., Fahey, B. (1983). More operating rooms or better use of resources? *Nursing Management*. 14, 16-19.
- Tarantino, D. (2004). Process redesign Part 2: Process Analysis. *The Physician Executive*. jan-feb, 52-54.
- Thompson, T., & Brown, H. (2002). Turnover of licensed nurses in skilled nursing facilities. *Nursing Economics*. 20(2), 66-69.
- Trochim, W. (2001). *The Research Methods Knowledge Base* (2nd Ed.). Mason, OH: Atomic Dog Publishing.
- Tyler, D., Pasquariello, C., & Chen, C. (2003). Determining optimum operating room utilization. *Anesth Analg*. 96, 1114-1121.
- Van Ackere, A. (1990). Conflicting interests in the timing of jobs. *Management Science*. 36, 970-984.
- Weinbroum, A., Ekstein, P., Ezri, T. (2003). Efficiency of the operating room suite. *The American Journal of Surgery*. 185, 244-250.
- Yin, R. K. (2003). *Case Study Research: Design and Methods* (3rd Ed.). Thousand Oaks, CA: Sage Publications.

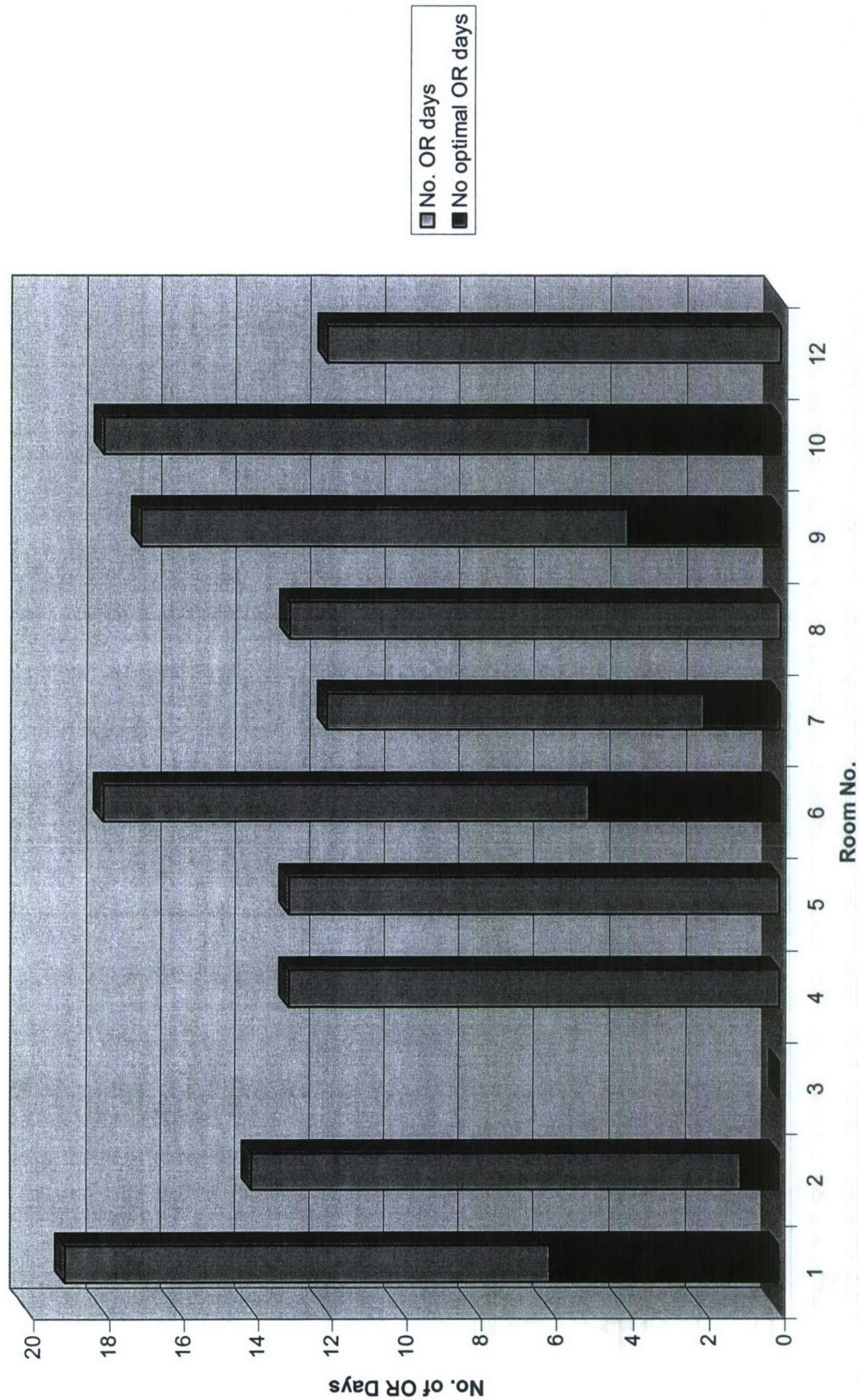
Appendix A

Tuesday OR Performance



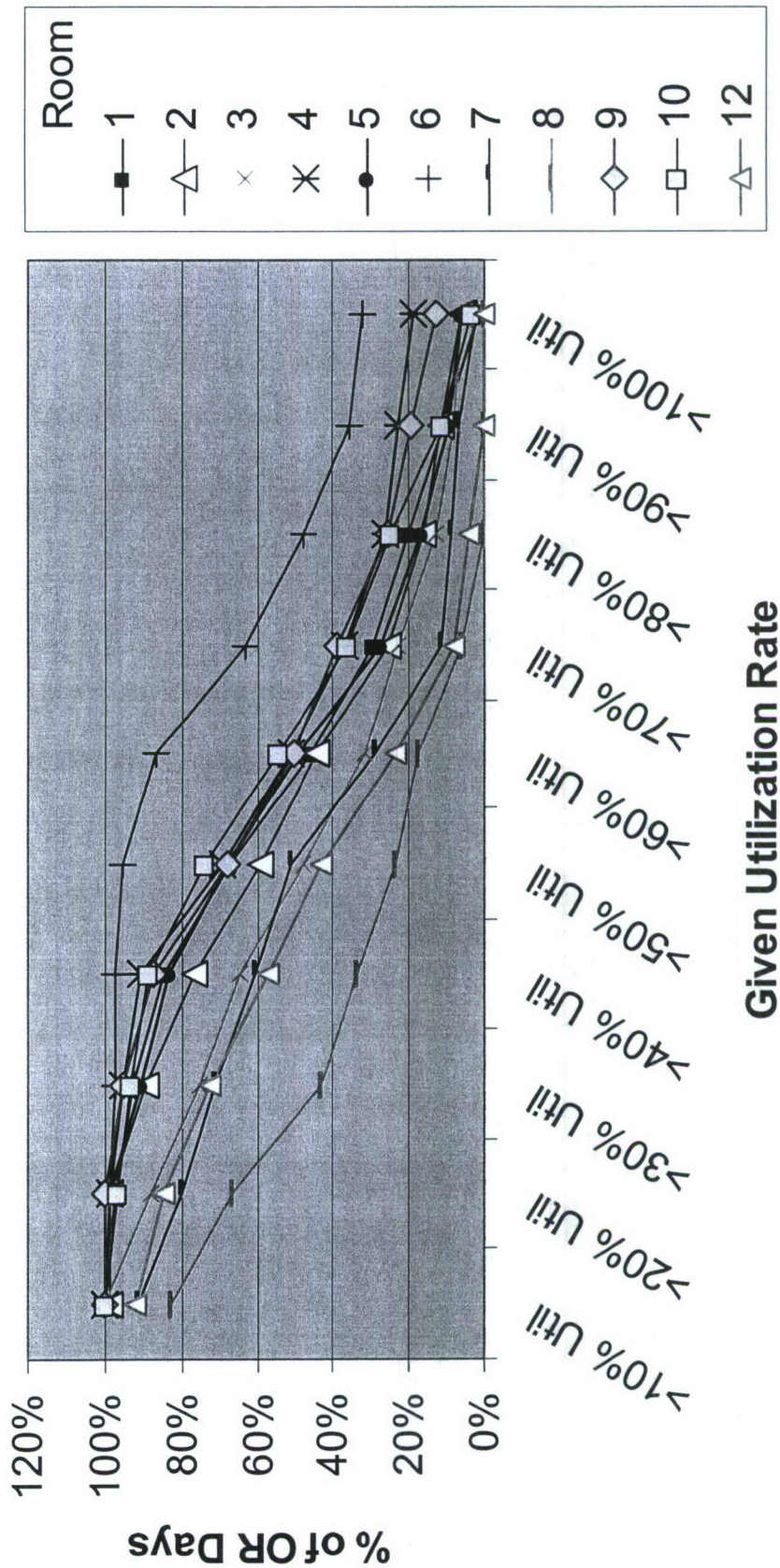
Appendix B

Thursday OR Performance



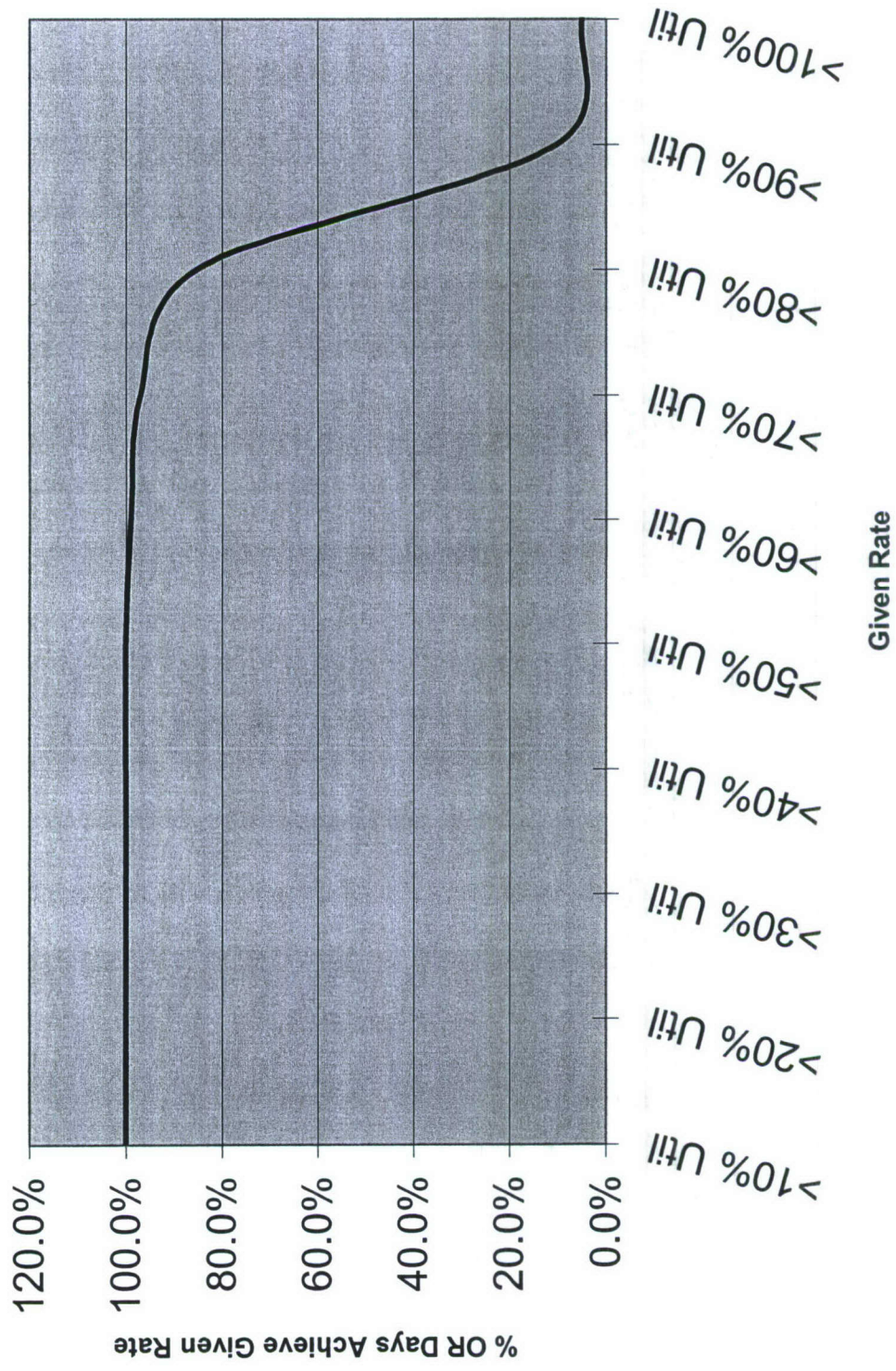
Appendix C

**% of OR Days Exceeding Given Utilization Rate
by OR**



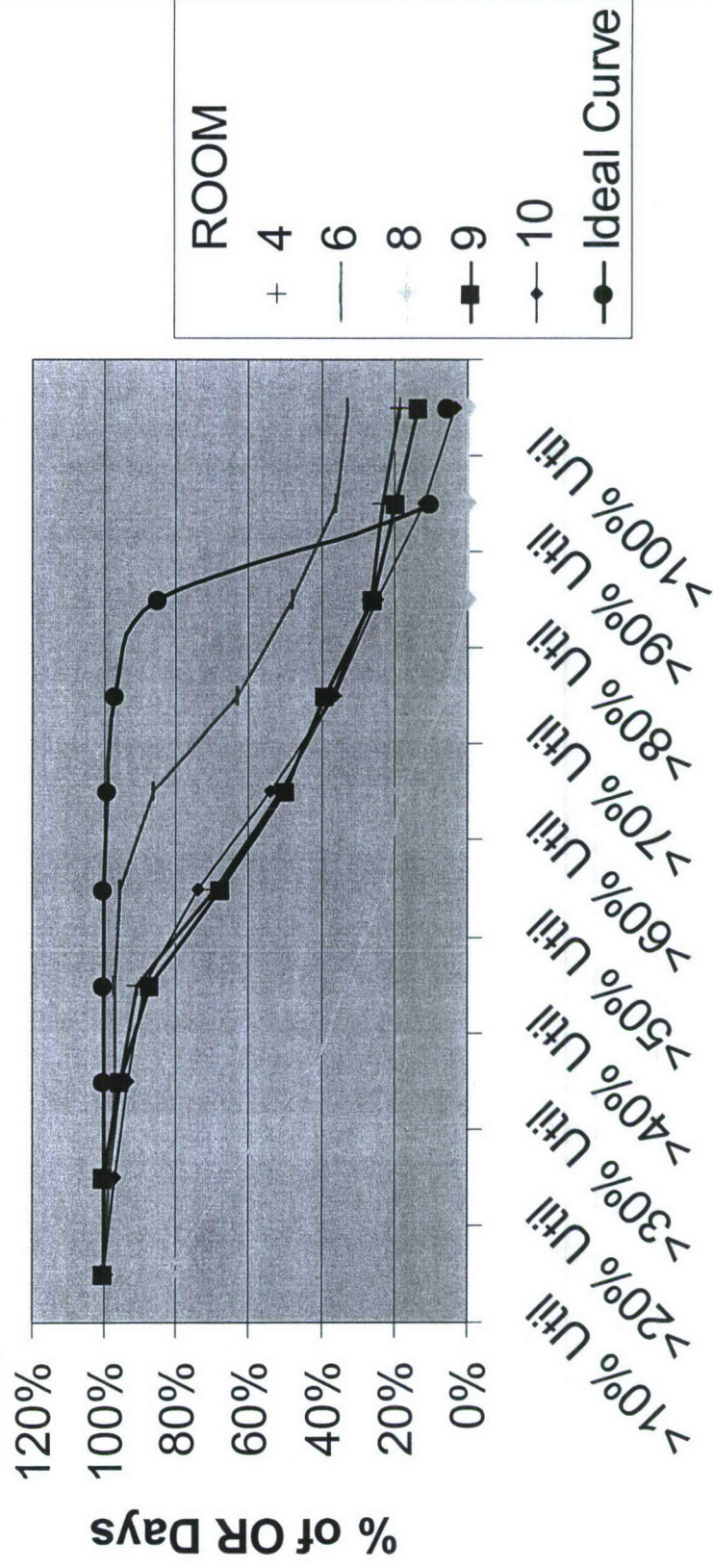
Appendix D

Ideal Curve



Appendix E

% of OR Days Exceeding Given Utilization Rate by OR



Given Utilization Rate

Appendix F

Definitions

(Allocated) Block-time – the time in minutes allocated daily for surgical groups during which only the corresponding group can schedule a surgery for an assigned operating room (OR).

(Allocated) Open-time – the time in minutes allocated daily to an OR for a surgical case.

Surgical Group- any group of surgeons, a single surgeon, surgical department or subspecialty, or combinations thereof which receive block time on the surgical block schedule.

Surgical Cluster – the grouping of surgeries by type to one of three clusters; General, Thoracic, Vascular, Otorhinolaryngology, Plastics and Cardiology are Cluster 1. Gynecology, Urology and Ophthalmology are Cluster 2. Orthopedics, Neurosurgery, Oral-Maxillofacial, Dental, and podiatry are Cluster 3.

Turnover time - the time a patient leaves an operating room until a new patient enters the operating room.

Start Delay - the time in minutes that measures the difference between when the surgical block schedule states an OR will open and when the first patient of the day enters the room.

Case Minutes/utilization - the number of minutes actually used for surgeries, starts when a patient enters the room and stops when a patient leaves the room.

Under-utilized/ Idle time – OR time allocated and staffed but not used for actual surgery or turn around time.

Over-Utilization – the number of minutes actually used for surgery that exceeds the number of minutes allocated for block-time and/or open-time.

Optimum-Utilization – a utilization rate that is greater or equal to 80% for a given OR day.